Regenerative Filtration Test Methodology

2004 Joint Scientific Conference on Chemical & Biological Defense Research

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16 November 2004

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
16 NOV 2004	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Regenerative Filtration Test Methodology	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **CBR Filtration Team Research and Technology Directorate Edgewood Chemical Biological Center**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM001849, 2004 Scientific Conference on Chemical and Biological Defense Research. Held in Hunt Valley, Maryland on 15-17 November 2004 . , The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**18**	

Introduction

- The current single-pass (consumable) filter technology is designed around a very specific CBRN threat composed of verified design-limiting vapors.
- Regenerative filtration technology offers the promise of greater capacity and breadth of chemical protection than the currently fielded single pass filter technology.
- Due to its complexity relative to single-pass technology, test methods must be developed to successfully transition regenerative filtration technology.

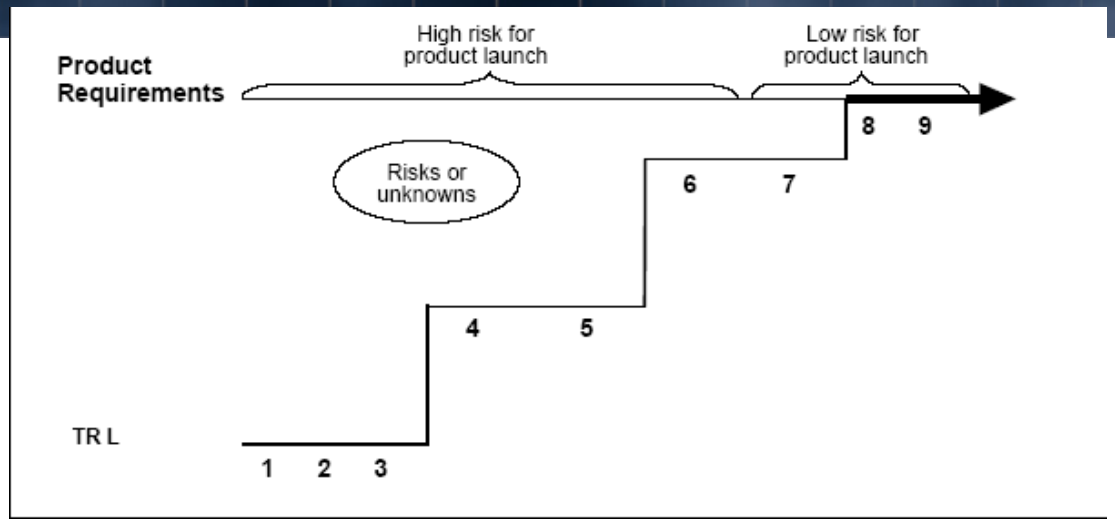
Objective

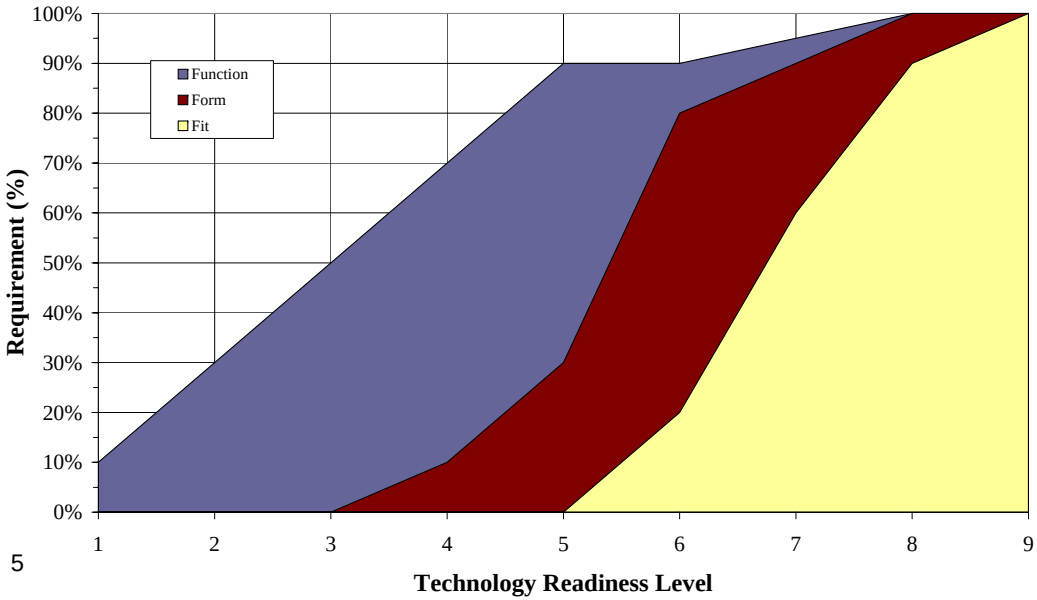
- Create an environment favorable for the transition of regenerative filtration technology.

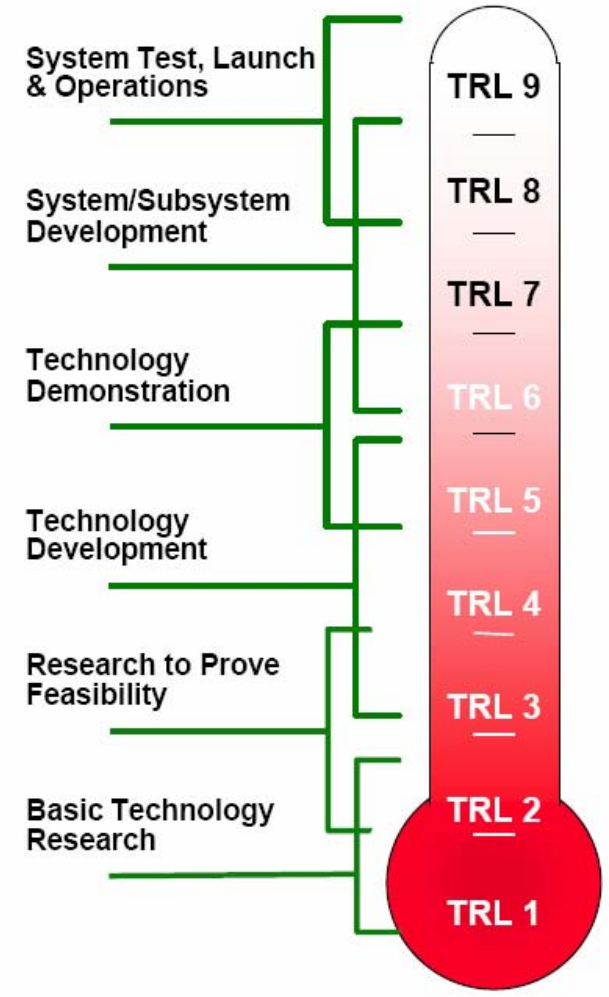
Approach

- Develop technology readiness level (TRL) definitions for regenerative filtration technologies.
- Use these definitions to create test and evaluation standards.

TRL Background



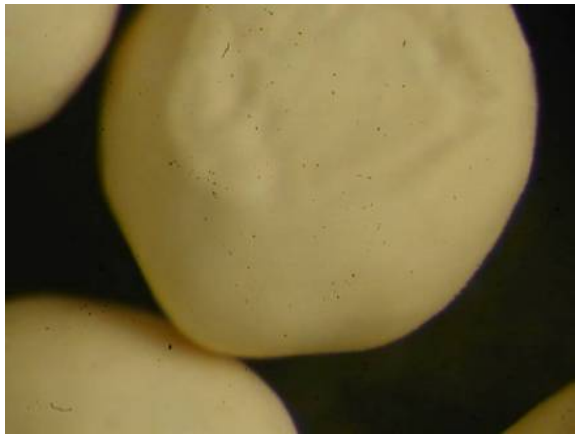


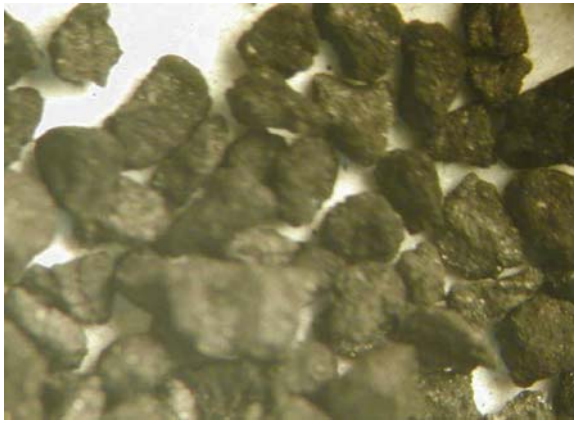


TRL 1

Basic principles observed and reported

- Demonstrate that the adsorbent media can provide the basic purification capability across the broad range of CWA/TIC vapors.

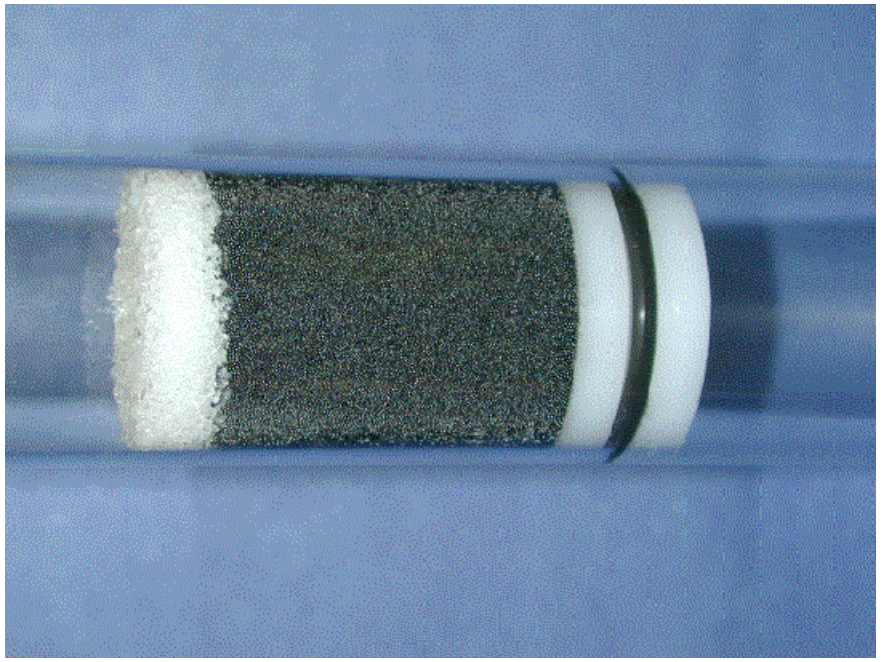




TRL 2

Technology concept and/or application formulated

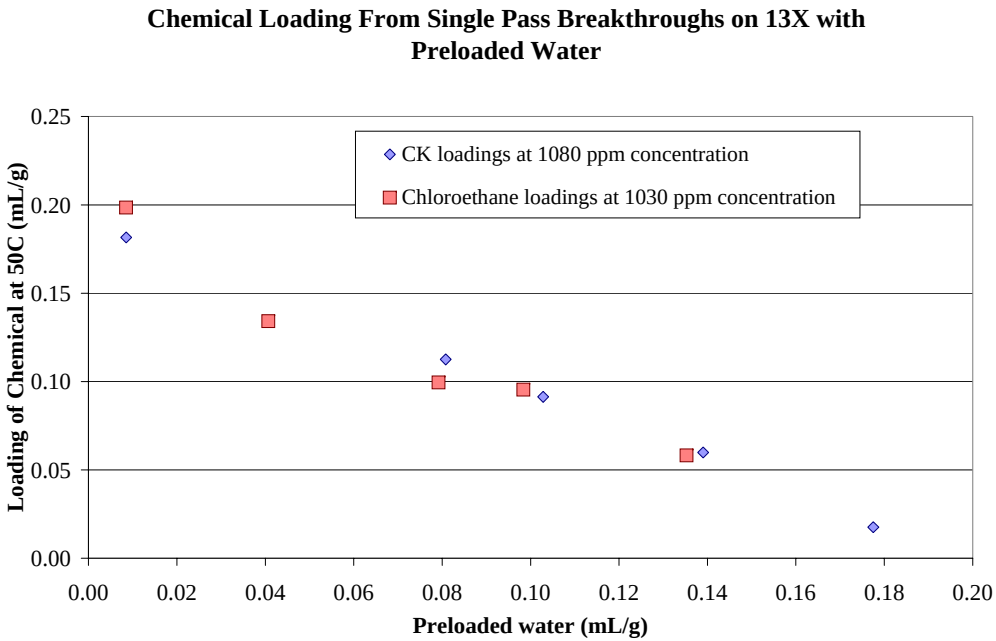
- Adsorbent weight and volume are reasonable.
- Understand the effects of relative humidity and temperature on adsorption capacity.
- Identify physical shortcomings of the adsorbent.
- Verify mass transfer rates and pressure drop are reasonable.



TRL 3

Characteristic proof of concept

- Identify design limiting CWA/TIC(s) for adsorption and desorption.
- Select and demonstrate simulants for the design limiting CWA/TICs.
- Quantify the relationship between inlet relative humidity, adsorbent volume, and regeneration energy.
- Identify a potential application, suggest a cycle, identify ECU requirements, and determine if the available resources can maintain desired operating bounds.



TRL 4

Breadboard validation in laboratory environment

- A laboratory-scale cyclic adsorption unit is designed and built.
- Simulant testing is conducted using cycles to validate previous modeling and establish design-limiting conditions for cycles.
- A limited amount of agent testing is performed to validate CWA performance and simulant correlation.
- System scale-up relationships are developed.

TRL 5

Breadboard validation in relevant environment

- Demonstrate the performance of a full-scale system under design-limiting conditions for the design limiting chemical(s).
- Improve the modeling capability to include scale-up relationships.
- Identify the customer, the specific application, and determine the feasibility of the technology within that application.
- Show that the potential risk of installing the system into the specific application and having the system perform as expected is low.
- Define the access and control that the Regen system designer has with respect to the application resources.

TRL 6

Prototype demonstrated in a relevant environment

- Establish that the Regen system can be integrated into the chosen application without adversely impacting performance or cost.

- For those components where little previous data is available, make sure that these are rugged enough to meet the environmental and rough handling tests that will be performed later.

- Understand completely how the system will be tested and evaluated.

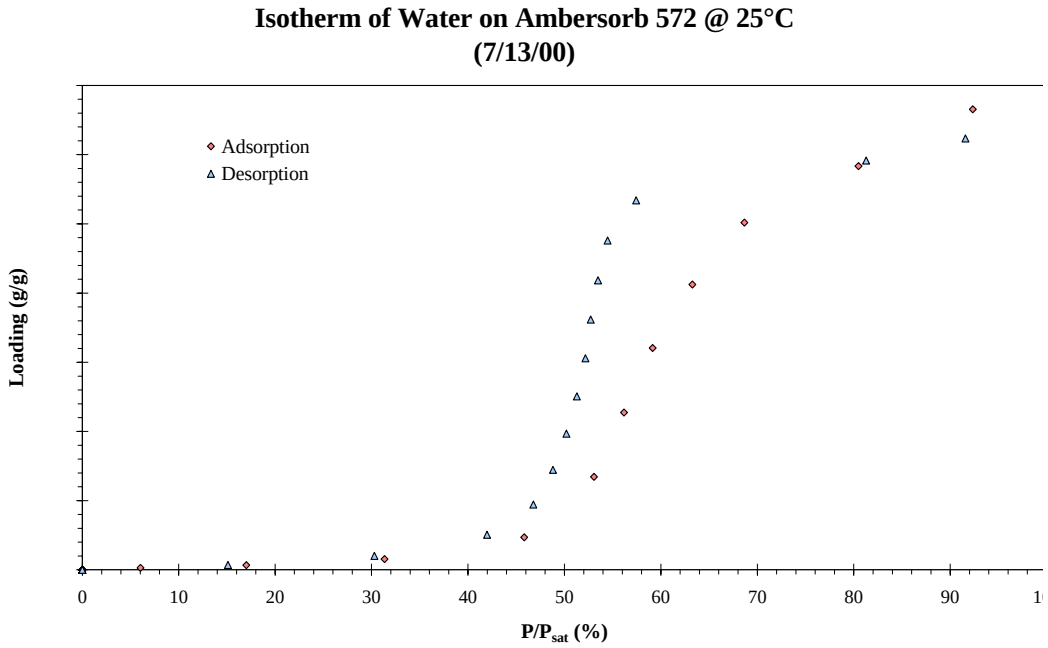
Regen Test Methods

- Adsorption equilibrium
- Breakthrough – Adsorption and desorption
- Cyclic steady state
- Regen chemical delivery sensitivities

Adsorption Equilibrium

Supports TRLs 1 through 6

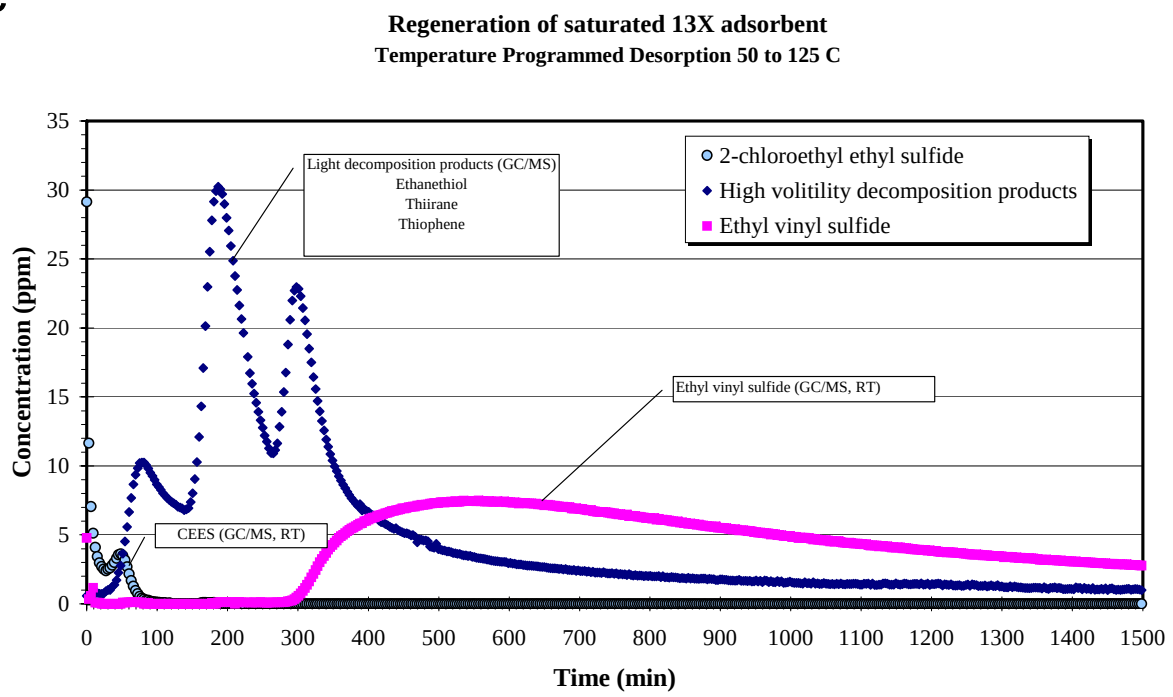
- Characterize equilibrium loading as a function of vapor concentration, temperature, and relative humidity.
  - Demonstration of practical separation (g chem./cc ads)
  - Design limiting chemical selection
  - Simulant correlation
  - Relative humidity effects
  - Presence of reaction?



Single pass breakthrough

Key TRL 3 tool, supports TRLs 3 through 6

- Characterize dynamic adsorption and desorption
  - Pressure drop
  - Mass transfer rates
  - Dispersion effects
  - Reaction
- Examine sensitivities
  - Vapor concentration
  - Temperature
  - Relative humidity
  - Velocity.



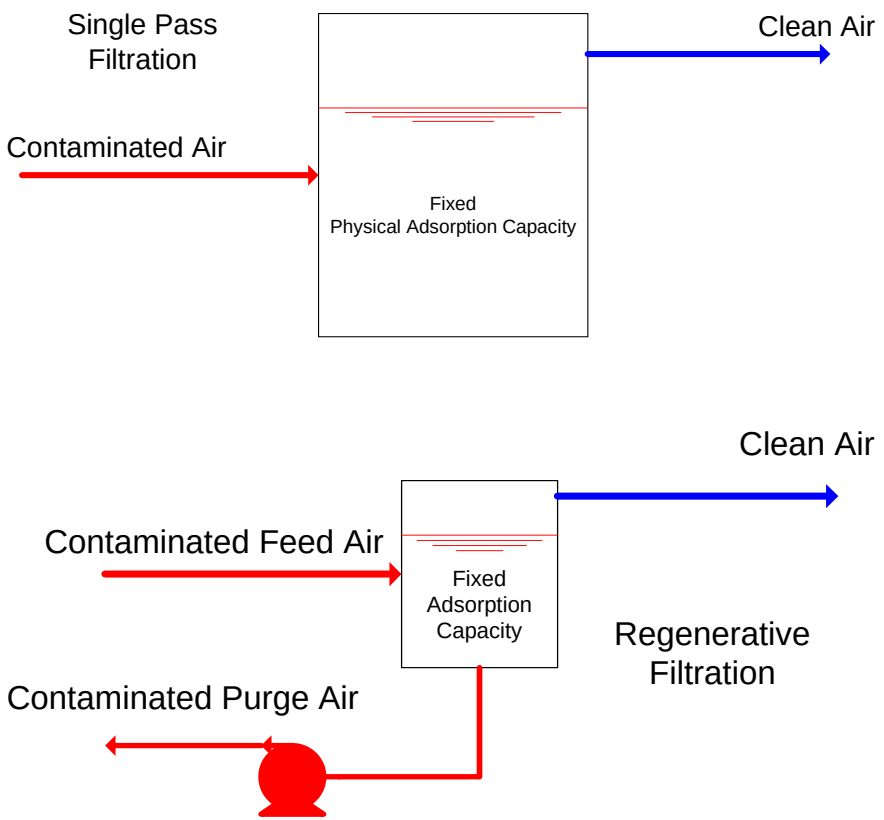
Cyclic Steady State

Key system performance testing requirement, supports TRLs 4 through 6

- Water is a major competitor for adsorption sites and must be accounted for in any chemical evaluation.
- No chemical test can characterize Regen system performance unless the system first has come to a cyclic steady state.
- Cyclic steady-state is defined as the point at which the water, temperature, and pressure profile for each cyclic adsorbent unit does not change for a given step from cycle to cycle.

Regen chemical delivery sensitivities

- Single pass filters have their capacity defined in terms of CT (conc. x time).
- This is a misleading indicator for Regen.
- Regen chemical delivery must be close to the application's threat to account for performance sensitivities to:
  - # of attacks
  - Dosage per attack
  - Peak concentration
  - Frequency of attacks
- Regen systems can succeed or fail for a given CT if any of these variables are changed.



Conclusions

- The sensitivities and complexities of regenerative filtration requires consideration of integration at an early developmental stage.
- Gathering the proper lab-scale data can help reduce the burden and expense of full-flow testing.
- Each regenerative filtration system is a unique test article.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